CLAIMS

1. A method of transmitting data in a wireless multiple-access multiple-input multiple-output (MIMO) communication system, comprising:

selecting at least one user terminal for data transmission;

selecting a spatial multiplexing mode, from among a plurality of spatial multiplexing modes supported by the system, to use for the at least one user terminal;

selecting a plurality of rates for a plurality of data streams to be transmitted via a plurality of spatial channels of a MIMO channel for the at least one user terminal; and

scheduling the at least one user terminal for data transmission with the plurality of selected rates and the selected spatial multiplexing mode.

2. The method of claim 1, wherein one user terminal is selected for data transmission and the selected spatial multiplexing mode is a steered spatial multiplexing mode.

3. The method of claim 2, further comprising:

spatially processing the plurality of data streams with a plurality of steering vectors to transmit the plurality of data streams on orthogonal spatial channels to the one user terminal.

4. The method of claim 1, wherein one user terminal is selected for data transmission and the selected spatial multiplexing mode is a non-steered spatial multiplexing mode.

5. The method of claim 4, further comprising:

providing the plurality of data streams for transmission from a plurality of antennas to the one user terminal.

6. The method of claim 1, wherein a plurality of user terminals are selected for data transmission and the selected spatial multiplexing mode is a steered spatial multiplexing mode.

7. The method of claim 6, further comprising:

spatially processing the plurality of data streams with a plurality of steering vectors to steer the plurality of data streams to the plurality of user terminals.

8. The method of claim 6, further comprising:

performing receiver spatial processing on a plurality of received symbol streams to obtain estimates of the plurality of data streams transmitted by the plurality of user terminals, wherein each data stream is processed with a respective steering vector to steer the data stream.

9. The method of claim 1, wherein a plurality of user terminals are selected for data transmission and the selected spatial multiplexing mode is a non-steered spatial multiplexing mode.

10. The method of claim 9, further comprising:

performing receiver spatial processing on a plurality of received symbol streams to obtain estimates of the plurality of data streams transmitted by the plurality of user terminals.

11. The method of claim 9, further comprising:

providing the plurality of data streams for transmission from a plurality of antennas to the plurality of user terminals each having multiple antennas.

12. The method of claim 1, wherein the MIMO system is a time division duplex (TDD) system.

13. The method of claim 12, wherein the selected spatial multiplexing mode is a steered spatial multiplexing mode if the at least one user terminal is calibrated and downlink channel response is reciprocal of uplink channel response.

14. The method of claim 12, wherein the selected spatial multiplexing mode is a non-steered spatial multiplexing mode if the at least one user terminal is

uncalibrated and downlink channel response is not reciprocal of uplink channel response.

15. The method of claim 1, wherein the selecting a plurality of rates includes

estimating signal-to-noise-and-interference ratios (SNRs) of the plurality of spatial channels, and

selecting the plurality of rates based on the estimated SNRs of the plurality of spatial channels.

16. An apparatus in a wireless multiple-access multiple-input multiple-output (MIMO) communication system, comprising:

a terminal selector operative to select at least one user terminal for data transmission;

a mode selector operative to select a spatial multiplexing mode, from among a plurality of spatial multiplexing modes supported by the system, to use for the at least one user terminal;

a rate selector operative to select a plurality of rates for a plurality of data streams to be transmitted via a plurality of spatial channels of a MIMO channel for the at least one user terminal; and

a scheduler operative to schedule the at least one user terminal for data transmission with the plurality of selected rates and the selected spatial multiplexing mode.

17. The apparatus of claim 16, further comprising:

a transmit spatial processor operative to spatially process the plurality of data streams in accordance with the selected spatial multiplexing mode to obtain a plurality of transmit symbol streams for transmission from a plurality of antennas to the at least one user terminal.

18. The apparatus of claim 16, further comprising:

a receive spatial processor operative to spatially process a plurality of received symbol streams in accordance with the selected spatial multiplexing mode to obtain estimates of the plurality of data streams transmitted by the at least one user terminal.

19. An apparatus in a wireless multiple-access multiple-input multiple-output (MIMO) communication system, comprising:

means for selecting at least one user terminal for data transmission;

means for selecting a spatial multiplexing mode, from among a plurality of spatial multiplexing modes supported by the system, to use for the at least one user terminal;

means for selecting a plurality of rates for a plurality of data streams to be transmitted via a plurality of spatial channels of a MIMO channel for the at least one user terminal; and

means for scheduling the at least one user terminal for data transmission with the plurality of selected rates and the selected spatial multiplexing mode.

20. The apparatus of claim 19, further comprising:

means for spatially processing the plurality of data streams in accordance with the selected spatial multiplexing mode to obtain a plurality of transmit symbol streams for transmission from a plurality of antennas to the at least one user terminal.

21. The apparatus of claim 19, further comprising:

means for spatially processing a plurality of received symbol streams in accordance with the selected spatial multiplexing mode to obtain estimates of the plurality of data streams transmitted by the at least one user terminal.

22. A method of transmitting data in a wireless multiple-access multiple-input multiple-output (MIMO) communication system, comprising:

selecting a first user terminal for data transmission in a first transmission interval;

selecting a first spatial multiplexing mode to use for the first user terminal;

selecting a second user terminal for data transmission in a second transmission interval;

selecting a second spatial multiplexing mode to use for the second user terminal;

scheduling the first user terminal for data transmission in the first transmission interval with the first spatial multiplexing mode; and

scheduling the second user terminal for data transmission in the second transmission interval with the second spatial multiplexing mode.

23. The method of claim 22, wherein the first spatial multiplexing mode is a steered spatial multiplexing mode and the second spatial multiplexing mode is a non-steered spatial multiplexing mode.

24. The method of claim 23, further comprising:

spatially processing a first plurality of data streams with a plurality of steering vectors to transmit the first plurality of data streams on orthogonal spatial channels of a MIMO channel for the first user terminal; and

providing a second plurality of data streams for transmission from a plurality of antennas to the second user terminal.

25. The method of claim 23, further comprising:

performing receiver spatial processing on a first plurality of received symbol streams with a plurality of eigenvectors to obtain estimates of a first plurality of data streams transmitted by the first user terminal; and

performing receiver spatial processing on a second plurality of received symbol streams in accordance with a spatial filter to obtain estimates of a second plurality of data streams transmitted by the second user terminal.

26. The method of claim 23, further comprising:

selecting a first plurality of rates for a first plurality of data streams to be transmitted via a first plurality of spatial channels of a first MIMO channel for the first user terminal; and

selecting a second plurality of rates for a second plurality of data streams to be transmitted via a second plurality of spatial channels of a second MIMO channel for the second user terminal, and

wherein the first user terminal is further scheduled with the first plurality of rates and the second user terminal is scheduled with the second plurality of rates.

27. An apparatus in a wireless multiple-access multiple-input multiple-output (MIMO) communication system, comprising:

a user selector operative to select a first user terminal for data transmission in a first transmission interval and to select a second user terminal for data transmission in a second transmission interval;

a mode selector operative to select a first spatial multiplexing mode to use for the first user terminal and to select a second spatial multiplexing mode to use for the second user terminal; and

a scheduler operative to schedule the first user terminal for data transmission in the first transmission interval with the first spatial multiplexing mode and to schedule the second user terminal for data transmission in the second transmission interval with the second spatial multiplexing mode.

28. The apparatus of claim 27, wherein the first spatial multiplexing mode is a steered spatial multiplexing mode and the second spatial multiplexing mode is a non-steered spatial multiplexing mode.

29. The apparatus of claim 28, further comprising:

a transmit spatial processor operative to

spatially process a first plurality of data streams with a plurality of steering vectors to transmit the first plurality of data streams on orthogonal spatial channels of a MIMO channel for the first user terminal, and

provide a second plurality of data streams for transmission from a plurality of antennas to the second user terminal.

30. The apparatus of claim 28, further comprising:

a receive spatial processor operative to

perform receiver spatial processing on a first plurality of received symbol streams with a plurality of eigenvectors to obtain estimates of a first plurality of data streams transmitted by the first user terminal, and

perform receiver spatial processing on a second plurality of received symbol streams in accordance with a spatial filter to obtain estimates of a second plurality of data streams transmitted by the second user terminal.

31. An apparatus in a wireless multiple-access multiple-input multiple-output (MIMO) communication system, comprising:

means for selecting a first user terminal for data transmission in a first transmission interval;

means for selecting a first spatial multiplexing mode to use for the first user terminal;

means for selecting a second user terminal for data transmission in a second transmission interval;

means for selecting a second spatial multiplexing mode to use for the second user terminal;

means for scheduling the first user terminal for data transmission in the first transmission interval with the first spatial multiplexing mode; and

means for scheduling the second user terminal for data transmission in the second transmission interval with the second spatial multiplexing mode.

32. The apparatus of claim 31, wherein the first spatial multiplexing mode is a steered spatial multiplexing mode and the second spatial multiplexing mode is a non-steered spatial multiplexing mode.

33. The apparatus of claim 32, further comprising:

means for spatially processing a first plurality of data streams with a plurality of steering vectors to transmit the first plurality of data streams on orthogonal spatial channels of a MIMO channel for the first user terminal; and

means for providing a second plurality of data streams for transmission from a plurality of antennas to the second user terminal.

34. The apparatus of claim 32, further comprising:

means for performing receiver spatial processing on a first plurality of received symbol streams with a plurality of eigenvectors to obtain estimates of a first plurality of data streams transmitted by the first user terminal; and

means for performing receiver spatial processing on a second plurality of received symbol streams in accordance with a spatial filter to obtain estimates of a second plurality of data streams transmitted by the second user terminal.

35. A method of transmitting data in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

coding and modulating a first plurality of data streams to obtain a first plurality of data symbol streams;

spatially processing the first plurality of data symbol streams with a first plurality of steering vectors to obtain a first plurality of transmit symbol streams for transmission from a plurality of antennas to a first user terminal in a first transmission interval;

coding and modulating a second plurality of data streams to obtain a second plurality of data symbol streams; and

providing the second plurality of data symbol streams as a second plurality of transmit symbol streams for transmission from the plurality of antennas to a second user terminal in a second transmission interval.

36. The method of claim 35, further comprising:

deriving the first plurality of steering vectors such that the first plurality of data streams are transmitted on a plurality of orthogonal spatial channels of a first MIMO channel for the first user terminal.

37. The method of claim 35, further comprising:

coding and modulating a third plurality of data streams to obtain a third plurality of data symbol streams; and

spatially processing the third plurality of data symbol streams with a second plurality of steering vectors to obtain a third plurality of transmit symbol streams for transmission from the plurality of antennas to a plurality of user terminals in a third transmission interval.

38. The method of claim 37, further comprising:

deriving the second plurality of steering vectors such that the third plurality of data streams are received with suppressed crosstalk at the plurality of user terminals.

39. An apparatus in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

a transmit data processor operative to

code and modulate a first plurality of data streams to obtain a first plurality of data symbol streams, and

code and modulate a second plurality of data streams to obtain a second plurality of data symbol streams; and

a transmit spatial processor operative to

spatially process the first plurality of data symbol streams with a first plurality of steering vectors to obtain a first plurality of transmit symbol streams for transmission from a plurality of antennas to a first user terminal in a first transmission interval, and

provide the second plurality of data symbol streams as a second plurality of transmit symbol streams for transmission from the plurality of antennas to a second user terminal in a second transmission interval.

40. A method of receiving data in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

performing receiver spatial processing on a first plurality of received symbol streams in accordance with a first spatial multiplexing mode to obtain a first plurality of recovered data symbol streams;

demodulating and decoding the first plurality of recovered data symbol streams in accordance with a first plurality of rates to obtain a first plurality of decoded data streams;

performing receiver spatial processing on a second plurality of received symbol streams in accordance with a second spatial multiplexing mode to obtain a second plurality of recovered data symbol streams; and

demodulating and decoding the second plurality of recovered data symbol streams in accordance with a second plurality of rates to obtain a second plurality of decoded data streams.

41. The method of claim 40, wherein the first spatial multiplexing mode is a steered spatial multiplexing mode, and wherein the first plurality of received symbol streams are spatially processed with a plurality of eigenvectors for a plurality of spatial channels of a MIMO channel for a user terminal.

42. The method of claim 40, wherein the second spatial multiplexing mode is a non-steered spatial multiplexing mode.

43. The method of claim 42, wherein the second plurality of decoded data streams are estimates of a plurality of data streams transmitted by a single user terminal.

44. The method of claim 42, wherein the second plurality of decoded data streams are estimates of a plurality of data streams transmitted simultaneously by a plurality of user terminals.

45. The method of claim 42, wherein the second plurality of received symbol streams are spatially processed based on a channel correlation matrix inversion (CCMI) technique.

46. The method of claim 42, wherein the second plurality of received symbol streams are spatially processed based on a minimum mean square error (MMSE) technique.

47. The method of claim 42, wherein the second plurality of received symbol streams are spatially processed based on a successive interference cancellation (SIC) technique.

48. An apparatus in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

a receive spatial processor operative to

perform receiver spatial processing on a first plurality of received symbol streams in accordance with a first spatial multiplexing mode to obtain a first plurality of recovered data symbol streams, and

perform receiver spatial processing on a second plurality of received symbol streams in accordance with a second spatial multiplexing mode to obtain a second plurality of recovered data symbol streams; and

a receive data processor operative to

demodulate and decode the first plurality of recovered data symbol streams in accordance with a first plurality of rates to obtain a first plurality of decoded data streams, and

demodulate and decode the second plurality of recovered data symbol streams in accordance with a second plurality of rates to obtain a second plurality of decoded data streams.

49. A method of transmitting data in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

receiving information indicating a spatial multiplexing mode and a plurality of rates to use for data transmission, wherein the spatial multiplexing mode is selected from among a plurality of spatial multiplexing modes supported by the system, and wherein each of the plurality of rates is selected from among a set of rates supported by the system;

coding and modulating a plurality of data streams in accordance with the plurality of rates to obtain a plurality of data symbol streams; and

spatially processing the plurality of data symbol streams in accordance with the spatial multiplexing mode to obtain a plurality of transmit symbol streams for transmission from a plurality of antennas.

50. The method of claim 49, wherein the spatial multiplexing mode is a steered spatial multiplexing mode, and wherein the plurality of data symbol streams are spatially processed with a plurality of steering vectors to transmit the plurality of data symbol streams on a plurality of orthogonal spatial channels of a MIMO channel.

51. The method of claim 50, further comprising:

transmitting a steered pilot on each of the plurality of orthogonal spatial channels.

52. The method of claim 49, wherein the spatial multiplexing mode is a non-steered spatial multiplexing mode, and wherein the plurality of data symbol streams are provided as the plurality of transmit symbol streams.

53. The method of claim 49, further comprising:

performing calibration so that uplink channel response is reciprocal of downlink channel response.

54. An apparatus in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

a controller operative to receive information indicating a spatial multiplexing mode and a plurality of rates to use for data transmission, wherein the spatial multiplexing mode is selected from among a plurality of spatial multiplexing modes supported by the system, and wherein each of the plurality of rates is selected from among a set of rates supported by the system;

a transmit data processor operative to code and modulate a plurality of data streams in accordance with the plurality of rates to obtain a plurality of data symbol streams; and

a transmit spatial processor operative to spatially process the plurality of data symbol streams in accordance with the spatial multiplexing mode to obtain a plurality of transmit symbol streams for transmission from a plurality of antennas.

55. A method of receiving data in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

receiving information indicating a spatial multiplexing mode and at least one rate to use for data transmission, wherein the spatial multiplexing mode is selected from among a plurality of spatial multiplexing modes supported by the system, and wherein each of the at least one rate is selected from among a set of rates supported by the system;

spatially processing at least one received symbol stream in accordance with the spatial multiplexing mode to obtain at least one recovered data symbol stream; and

demodulating and decoding the at least one recovered data symbol stream in accordance with the at least one rate to obtain at least one decoded data stream.

56. The method of claim 55, wherein the spatial multiplexing mode is a steered spatial multiplexing mode, and wherein a plurality of received symbol streams are spatially processed with a plurality of eigenvectors for a plurality of spatial channels of a MIMO channel to obtain a plurality of recovered data symbol streams.

57. The method of claim 55, wherein the spatial multiplexing mode is a non-steered spatial multiplexing mode.

58. The method of claim 57, wherein a plurality of received symbol streams are spatially processed based on a channel correlation matrix inversion (CCMI) technique, a minimum mean square error (MMSE) technique, or a successive interference cancellation (SIC) technique to obtain a plurality of recovered data symbol streams.

59. The method of claim 57, wherein one received symbol stream is processed with channel gain estimates to obtain one recovered data symbol stream.

60. An apparatus in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

a controller operative to receive information indicating a spatial multiplexing mode and at least one rate to use for data transmission, wherein the spatial multiplexing mode is selected from among a plurality of spatial multiplexing modes supported by the system, and wherein each of the at least one rate is selected from among a set of rates supported by the system;

a receive spatial processor operative to spatially process at least one received symbol stream in accordance with the spatial multiplexing mode to obtain at least one recovered data symbol stream; and

a receive data processor operative to demodulate and decode the at least one recovered data symbol stream in accordance with the at least one rate to obtain at least one decoded data stream.